

**V-02.01 General**

- Primary guidelines are those set forth in this manual and in the Code of Federal Regulations (23 CFR 650).
- A hydraulic review is required for rehabilitation projects if there is significant scour, unstable channels, or a history of high water problems.
- A hydraulic Report should be prepared for all new structures.
- A Water Surface Profile Analysis should be included in all hydraulic reports.

**V-02.02 Hydraulics Report**

Generally, a hydraulic report should be done for all locations where the 25-year event flow is greater than 500 cfs.

**V-02.02.1 Design Frequency**

For the design frequency to use for a certain classification of highway, refer to the Highway Classification Criteria-Design Flood Frequency Chart in Appendix V-01A.

**V-02.02.2 Contributing Drainage Area**

The first step should be to research old plans, files, special studies, etc. in an attempt to determine the values used in the previous construction.

If no previous data is available, United States Geological Survey (USGS) Quad Maps and the County Maps for the respective county should be used to delineate the drainage boundaries.

If previous data is available, confirm this data by again using the Quad and County maps.

Non-contributing areas such as sloughs should be noted.

**V-02.02.3 Design Flow**

Before the waterway opening can be determined, the volume of water flowing in the channel for the design parameters must be determined.

Priority should be given to discharges that have been determined in special flood studies or from stream gages. If this information is not available, the discharge must be calculated. There are a number of methods that could be used to calculate the discharge, but the method most commonly

used by the NDDOT can be found in a manual published by the USGS entitled “Techniques for Estimating Peak-Flow Frequency Relations for North Dakota Streams”(WRI-92-4020).

#### **V-02.02.4 Waterway Opening Requirements**

There are two main factors used in determining the size of the waterway needed. These are, design velocity and headwater limitations. (See the discussion of these factors in the paragraphs below). Other factors to consider are economics and special site conditions or there may be some other requirements to consider.

#### **V-02.02.5 Other Items in Hydraulic Report**

- Hydraulic analyses should compare water surface elevations which would result from the proposed structure with that of the existing structure.
- Scour analyses and recommended scour countermeasures should be addressed.
- If the structure is in a flood hazard area., it should be documented in the Hydraulic Report. If so, the new structure should not increase the 100 year stage by more than the amount allowed by FEMA regulations.
- Hydraulic data in the report should be shown on the plans.

#### **V-02.03 Design Velocity of Flow**

Generally, the maximum velocity for the design discharge is 5.0 ft./sec. for bridges or structures without a floor. For box culverts and other structures with a floor, the design velocity is normally 10.0 ft./sec. Higher or lower values may be used if it is deemed appropriate for a particular site.

#### **V-02.04 Allowable Headwater**

The hydraulic design must balance passing the design flow through the structure and yet not have an excessive headwater. The maximum headwater elevation should provide a reasonable freeboard against flooding the highway, but low enough so that it does not damage property upstream from the structure.

Consult the chart entitled “Highway Classification Criteria-Design Flood Frequency” (Appendix V-01 A) for criteria to use in determining the maximum headwater. Each site will, no doubt, have it’s own unique circumstances which should be considered.

**V-02.05 Flared End Sections, Head Walls, Drop Inlets, etc.**

Flared End sections are normally specified for all culverts. In some cases Head Walls may be needed or preferred. At locations where there is a rapid change in the channel gradient, Drop Inlets or special outlet devices may be necessary.

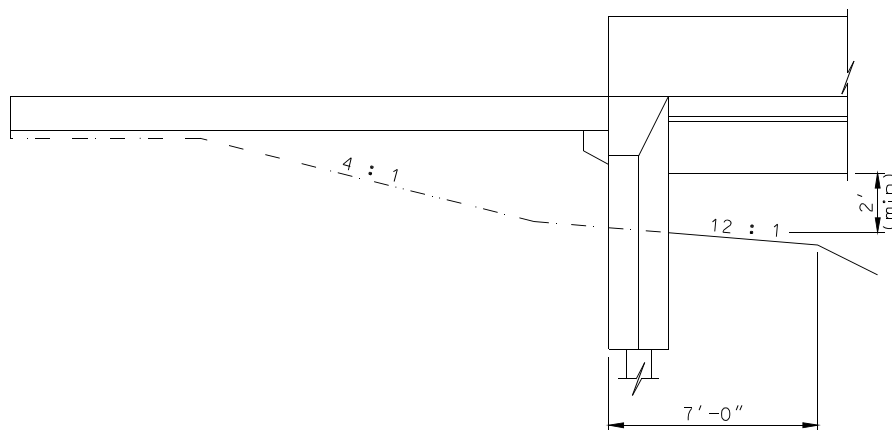
**V-02.06 Type, Size and Location Inspection (TS&L)**

When the Hydraulic Report has been completed a TS&L inspection should be held at the project site to discuss the structural recommendations. Particular items which should be discussed are as follows:

- Structure selection
- Whether to use a temporary bypass or a detour
- The need for riprap / scour countermeasures
- Disposal of the existing structure
- Utilities
- Right-of-Way
- Additional environmental concerns that may not have been addressed in the environmental documentation.

**V-02.07 Berms**

Berm widths of 7 feet, measured from the back face of the abutment to the top of the channel slope should be used. Also, the minimum clearance between the berm and the girders should be 2 feet.



**V-02.08 Reference Documents****V-02.08.1 Hydraulic Design Series (HDS)**

- HDS 1        Hydraulics of Bridge Waterways
- HDS 2        Highway Hydrology (SI)
- HDS 3        Design Charts for Open- Channel Flow
- HDS 4        Introduction to Highway Hydraulics (SI)
- HDS 5        Hydraulic Design of Highway Culverts

**V-02.08.2 Hydraulic Engineering Circulars (HEC)**

- HEC 9        Debris-Control Structures
- HEC 11       Design of Riprap Revetment
- HEC 14       Hydraulic Design of Energy Dissipaters for Culverts and Channels
- HEC 15       Design of Roadside Channels with Flexible Linings
- HEC 17       The Design of Encroachments on Flood Plains Using Risk Analysis
- HEC 18       Evaluating Scour at Bridges, Edition 3 (SI)
- HEC 20       Stream Stability at Highway Structures, Edition 2 (SI)
- HEC 21       Design of Bridge Deck Drainage
- HEC 22       Urban Drainage Design Manual (SI)
- HEC 23       Bridge Scour and Stream Instability Countermeasures (SI)

**V-02.08.3 Computer Programs**

- HY 8        Hydraulic Design of Highway Culverts
- HY 9        Scour at Bridges
- HYDRAIN    Drainage Design System (includes WSPRO & HY-8) This can be downloaded at no cost at: <http://www.fhwa.dot.gov/bridge/hydsoft.htm>
- HEC 2 Water Surface Profiles can be downloaded at no cost at: [http://www.hec.usace.army.mil/software/software\\_distrib/index.html](http://www.hec.usace.army.mil/software/software_distrib/index.html)
- HEC-HMS    Hydrologic Modeling System can be downloaded at no cost at the same address as HEC 2.
- HEC-RAS    River Analysis System can be downloaded at no cost at the same address as HEC 2.
- High Water Determination
- Culvert Headwater

**V-02.08.4 Other Reports and Computer Program User Manuals**

- Manual for Development of Highway Crossings at Streams (Hydraulic Manual)
- Highway Drainage Guidelines-AASHTO 1992

- WRI 92-4020 Techniques for Estimating Peak-Flow Frequency Relations for North Dakota Streams
- WRI 96-4178 Analysis of the Peak-Flow Gaging Network in North Dakota
- HIRE-Highways in the River Environment
  
- HY 7-User's Manual for WSPRO - A Computer Model for Water Surface Profile Computations
- HEC 2-User's Manual
- HEC-RAS-Applications Guide
- HEC-RAS-Hydraulic Reference Manual
- HEC-HMS-User's Manual